P126

Study of economically alloyed aluminum alloys by SEM and SPM

I.V. Shkalei[1], O.O. Shcherbakova[1], V.A. Lapitskaya[2]

[1]*Ishlinsky Institute for Problems in Mechanics RAS, 119526, Moscow, Russia*
ioann_shiva@list.ru

[2]*Heat and Mass Transfer Institute of NAS Belarus, 220072, Minsk, Belarus*

Aluminum alloys are promising materials used in various fields of engineering. In particular, they are widely used in the manufacture of bearing assemblies of various machines and mechanisms, where they are gradually replacing costly bronze [1]. In the present work, two economically doped aluminum-based alloys of the following composition were investigated:

No. 1 – Al-5% Si-4% Cu-4% Sn-0.5% Bi-0.5% Pb-0.5% Cd,

No. 2 – Al-5% Si-4% Cu-4% Sn-0.5% Bi-0.5% Pb.

These compositions were selected on the basis of the results obtained in [2].

The alloys were investigated before and after the tribological tests carried out according to the "shoe-roller" scheme (the studied alloy is a counter-body made of «Ст45» structural steel) [3]. The influence of structural changes at the surface during friction on the tribological properties of alloys was evaluated. Methods of scanning electron and probe microscopy were used to study the topography, composition, and properties of the surface and near-surface layers. Studies of the near-surface layers of the pads were carried out on the end sections. The following instruments were used in the work: SEM Quanta-650 (FEI) with analytical equipment EDAX and SPM Dimension FastScan (Bruker). SPM studies of the alloys were carried out in the PeakForce Tapping QNM mode using standard silicon cantilevers of the NSC-11 type (MicroMash) with a probe tip curvature radius of 29 nm and a console force-constant of 99.72 N/m. The probe makes an "approach" to the surface of the sample with recording force curves at each point of the image. Obtaining and recording such curves is the basis of the PeakForce QNM mode, which automatically recalculates the values of mechanical properties (modulus of elasticity and adhesion), taking into account the characteristics of the probe used.

Figure 1 shows the SEM image of a slice of the pads of alloy No. 2 after tribological tests at different pressures.

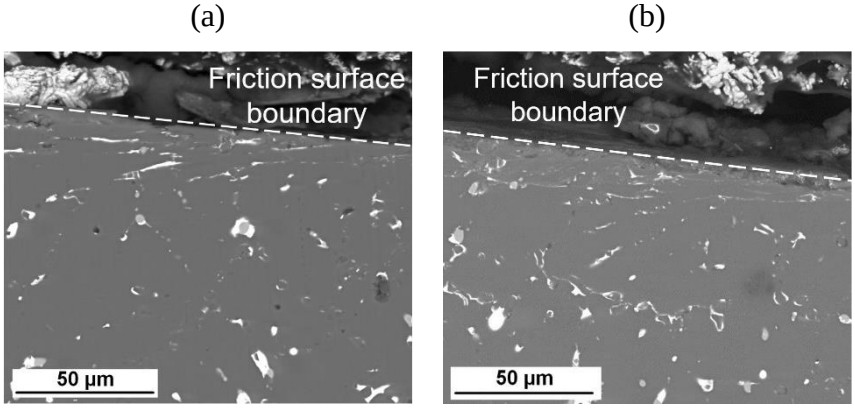

Figure 1. SEM-images of the slice of the block from alloy No. 2 after tribological tests at various pressures: (a) 0.5 MPa; (b) 1 MPa.

When studying sample slices, it can be seen that the structure in the near-surface region differs from structure in bulk. So, the phase components are traced in it in the direction of friction. This is due to the fact that in the process of friction in the surface layers there is a deformation of the dendritic cells of the aluminum matrix, leading to a change in the geometry of these components. The resulting images show that the differences between the alloys are small. The images allow us to estimate the thickness of the deformed layer: for both alloys, this is 20-30 μm (for pressures of 0.5 MPa) and 50-80 μm (for pressures of 1 MPa).

Figure 2 shows the SPM images of the surface morphology of alloy No. 2 after tribological tests.

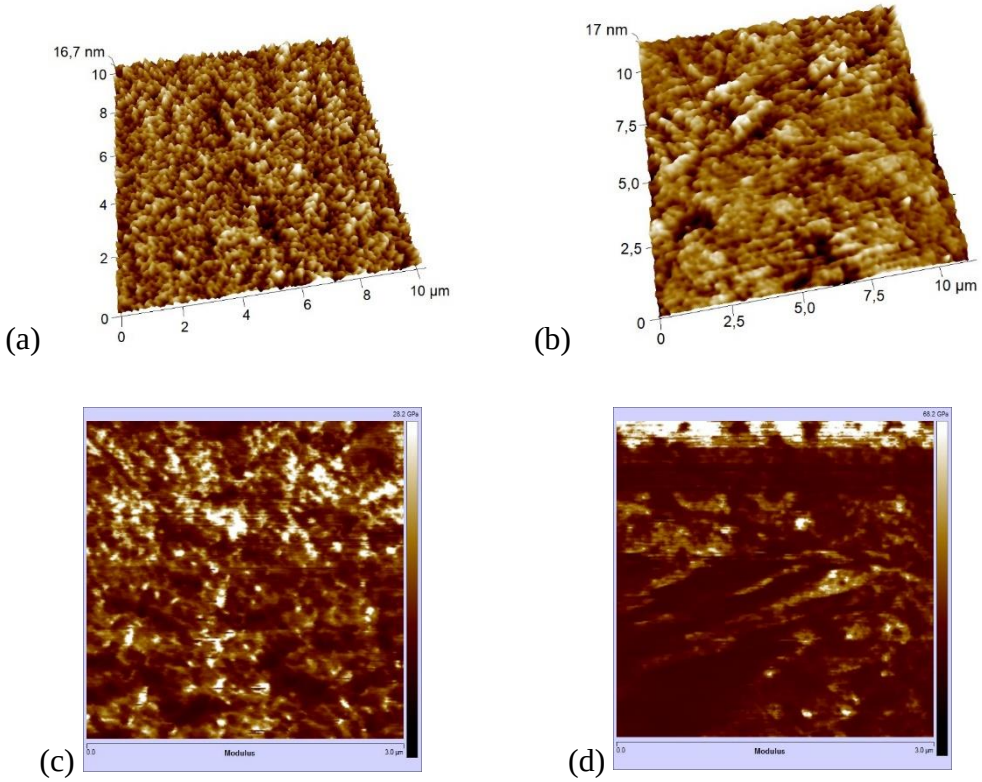

Figure 2. SPM-images of the cut of the surface of the shoe (alloy No. 2) after tribo-testing at a pressure of 1.0 MPa: (a) morphology of the surface layer, (b) morphology in the bulk, (c) modulus of elasticity of the surface layer, (d) modulus of elasticity in volume.

Table 1. The value of the elastic modulus at the cut of the alloy No. 2 at different distances from the boundary of the friction surface after tribological tests 1.0 MPa.

The distance from the friction boundary, µm	Elasticity modulus *E*, GPa
0-20	2.7
20-70	1.3
70-120	0.67
120-180	0.59
180-240	0.56
240-300	0.50

From Figure 2 and Table 1 it can be seen that the value of the elastic modulus in the near-surface layer of the alloy is significantly higher than in the volume: its values vary from 2,7 GPa to 0,6 GPa. This can be explained by the hardening of the alloy material in the process of friction.

This work was financially supported by the Russian Foundation for Basic Research (projects nos. 18-38-00289) (sample preparation) and partially supported by Grant of President of RF (MK-871.2018.8 No-AAAA-A18-118080290023-0) (microscopy investigations).

1. B.N. Arzamasov, T.V. Solov'eva, S.A. Gerasimov, et al., *Handbook of Structural Materials* (Moscow: Bauman MSTU), 640 (2005).
2. A.O. Yakovleva, N.A. Belov, T.A. Bazlova, I.V. Shkalei, *Phys. Met. Metallogr*+ **119**, 35 (2018).
3. B.Ya. Sachek, A.M. Mezrin, O.O. Shcherbakova, et al., *J. Frict. Wear* **39**, 259- (2018).